Conceptual Design of the PETRA III Orbit Feedback

K. Balewski, H.T Duhme, J. Klute, I. Krouptchenkov, R. Neumann, G. K. Sahoo, M. Wendt

Parameters:
- energy: 6 GeV
- current: 100 mA
- emittance: 1 nmrad
- straight sections: 9
- undulators: 13
- undulator length: 2, 5, 20 m
**PETRA III**

**Conversion of PETRA II (2304 m circ.)**

Conversion is going to start middle of 2007

Operation with beam should start in 2009

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**PETRA III**

**Optics old octant**

<table>
<thead>
<tr>
<th>element</th>
<th>Hor. (µm)</th>
<th>Ver. (µm)</th>
<th>Roll (mrad)</th>
<th>Long. (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>monitors</td>
<td>200</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad's old oct.</td>
<td>250</td>
<td>250</td>
<td>0.2</td>
<td>500</td>
</tr>
<tr>
<td>Dipoles</td>
<td>250</td>
<td>250</td>
<td>0.2</td>
<td>500</td>
</tr>
<tr>
<td>Sext.</td>
<td>250</td>
<td>250</td>
<td>0.2</td>
<td>500</td>
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</table>
PETRA III

damping wiggler $\varepsilon_x: 4 \rightarrow 1 \text{ mrad}$

Damping wigglers
- $B = 1.5 \text{ T}$
- $\lambda = 0.2 \text{ m}$
- $h = 0.025 \text{ m}$
- $L_{\text{tot}} = 80 \text{ m (2x40m)}$

PETRA III Optic new octant

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Dispersion limits to achieve design emittance

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<tbody>
<tr>
<td>Wiggler section</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Undulator’s (ID’s)</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>FODO arc</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>DBA</td>
<td>22</td>
<td>31</td>
</tr>
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Orbit stability goal

\[ \varepsilon_x = 1 \text{nmrad} \quad \text{coupling 1%} \]

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<tr>
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<th>Low ( \beta ) insertion</th>
<th>High ( \beta ) insertion</th>
</tr>
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<tbody>
<tr>
<td>( \beta ) (m)</td>
<td>( \sigma ) (( \mu )m)</td>
<td>( \sigma’ ) (( \mu )rad)</td>
</tr>
<tr>
<td>Horizontal</td>
<td>1.2</td>
<td>34.6</td>
</tr>
<tr>
<td>Vertical</td>
<td>3.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Stab. Requirement 0.1 * \( \sigma \)  
\( \rightarrow \) Sub micron orbit stability !!
1. Golden Orbit

Combined orbit and dispersion correction:

\[
\begin{bmatrix}
\alpha \vec{u} \\
(1-\alpha) D_u
\end{bmatrix} + \begin{bmatrix}
\alpha R \\
(1-\alpha) S
\end{bmatrix} \vec{\theta} = \vec{0}
\]

- \(u\) and \(D_u\) measured orbit or dispersion
- \(R\) and \(S\) orbit or dispersion response matrix
- \(\alpha\) weighting factor

Alternative: separated orbit & dispersion correction with skew quads

Elements for orbit correction

- 206 beam position monitors
- 182 horizontal correctors (resolution \(\geq 16\) bit)
  - 98 backleg windings on old dipoles
  - 18 backleg windings on new dipoles
  - 66 single correctors
- 189 vertical correctors (resolution \(\geq 18\) bit)
  - 91 additional windings on sextupoles
  - 98 single correctors

\(\Theta_{\text{max}} \approx 0.5\ mrad\ \ \ \ \ \ B^*l = 100\ Gm\)
2. Orbit stabilization

- top-up
- slow feedback: repeated orbit correction every few seconds
  - using all monitors and correctors via SVD algorithm
- fast feedback: BW few tenth of Hz up to 100 Hz

Fast orbit distortions in PETRA II

Fast feedback requirements: BW 100 Hz amplitude reduction factor ≤ 5
Elements for fast orbit correction

• **41 vertical & horizontal correctors** (air coils: Ωmax ≈ 5 µrad, B*I = 1 Gm)
  - 30 new octant (for orbit stabilisation)
  - 11 old octant (1 per short straight & 1 at the beginning and end of long straight section) to maintain small vertical emittance
• **Photon BPM’s (?)**

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<td>10</td>
<td>10</td>
</tr>
<tr>
<td>New octant</td>
<td>40</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
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<td>18</td>
<td>2</td>
<td>0.2</td>
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Position of Monitors & Correctors in DBA cell

- Monitors
- Horizontal Correctors
- Vertical Correctors
- Dipole
- QF
- QD
Rate of orbit measurements: ≥ 4 kHz
Data flow on cables (fiber optics) manageable
Digital controller (SVD & PID) feasible
Power supplies: work in progress
Correctors: air coils similar to ESRF
Long term stability
slow orbit feedback

- Alignment of the machine every half year
- Temperature stability (new octant \( \pm 0.1 \, ^\circ\text{C} \), old octant \( \pm 1 \, ^\circ\text{C} \))
- Cooling water temperature \( \pm 0.2 \, ^\circ\text{C} \)
- Establishing a new golden orbit \( \geq 24 \, \text{h} \)

ATL law:
\[
\Delta x^2 = A \cdot T \cdot L
\]

\( A = 4 \times 10^{-6} \, \text{µm}^2/\text{m/s} ; L = 65 \, \text{m} \)
\( \Delta x = 15 \, \text{µm} \)
\( \bar{T} = 10 \, \text{d} \)

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* Special supports for monitors close to ID's
Summary

• PETRA III is an unconventional Light Source
• Unconventional measures have to be taken to fulfill the stability requirements
• Nevertheless use can be made of the experience gained at other light sources concerning correction procedures and hardware design